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Microdoppler: NonCooperative Target Classification/Identification

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The augmentation of imaging systems with synergistic non-imaging systems such as a microdoppler radar has provided tactical combat systems with a beyond visual range capability for combat identification. The microdoppler technology has matured through technology feasibility demonstrations as part of the Navy's Low Probability of Intercept Advanced Technology Development program('92-'96) and Army's Advanced Concept and Technology II (ACT II) program('97). An overview of the Army ACT II will be discussed. The microdoppler radar system is now being transitioned onto operational systems in the Precision Targeting and Identification Advanced Concept Technology Demonstration program ('98-'02). Under the Precision Targeting and Identification Advanced Concept Technology Demonstration(PTI ACTD), a prototype system for airborne production will be tested at the Maui Space Surveillance Site as a visiting experiment in FY 2000.

Due to the need to extend the metric and space object identification capabilities of the MSSS, the augmentation of the Advanced Electro Optical System (AEOS) with a microdoppler capability using this existing system is being investigated and results for measuring microdoppler signatures of satellites out to 5000 km will be presented. Incorporating such a capability in AEOS will also provide DoD with an excellent testbed for future Space, Endo, and Ground Microdoppler signature and discrimination/ classification/ identification experiments.

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1. Introduction

Combat Identification Systems have a need to classify and identify targets detected at beyond visual range (BVR) as hostile, unknown, or friendly. Targets at BVR will be unresolved to existing tactical imaging cameras and will appear as dots on the operator's display which will make classification/identification of these targets using size and shape difficult.

This paper describes the use of a coherent detection ladar to classify airborne targets at BVR using the target's vibrational signatures caused by the aircraft's power plant. Incorporating this active sensor system into the Maui Space Surveillance Site(MSSS) for long range characterization of space objects will also be discussed.

A Multi-Functional Optical System (MFOS) Testbed (Figure 1-1) which was developed, maintained, and operated by Boeing (formerly McDonnell Douglas), and a coherent

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Optical Director/Turret

- Sensors
 - MWIR Camera
 - LWIR Camera
 - Visible Camera
 - Ladar
- Beam Expander
- Scan Mirror
- Ladar Power Supply
- Ladar Support Electronics
- Scan Controller
- Active Isolation
- Signal/Data/Control Links

Support Electronics Box

- Executive Controller
- Imaging Tracker
- Master Power Supply
- Thermal Control Unit

Controls and Display Console

- Situation Display
- Video Display
- Ladar Controller
- Turret Controller
- Ladar Signal Processor
- Classifier
- Hand Controller
- Signal/Data/Control Links

Figure 1-1 MultiFunctional Optical System Testbed

detection ladar, which was developed by Boeing (formerly Rockwell) for the Naval Air Warfare Center - Aircraft Division, Patuxent River, has been used to by the Navy and Army to validate the technical feasibility and proof of concept of microdoppler characterization of targets out to 20 km. The MFOS consists of a Mid-Wave Infrared (MWIR) camera, a Long-Wave Infrared (LWIR) camera, a visible CCD camera, and a ladar, all of which are mounted on a highly stabilized gimbal.

The MFOS testbed was used to detect, track, and classify airborne targets under simulated engagements. An overview a recently completed Army Advanced Concepts and Technology II program will be described to provide background on the capabilities of this technology.

The results of this test clearly demonstrated how an integrated coherent detection ladar on a stabilized gimbal can provide an adjunct to the radar for BVR classification and identification. This scenario at long ranges can also be employed by the MSSS for space object identification(SOI).

2. ACT II Objective

The objective of this Advanced Concept & Technology II (ACT II) program was to classify airborne targets in realistic engagement scenarios at BVR using a coherent detection ladar to measure the target's vibrational signatures caused by the aircraft's power plant. This classification, when used with other target metrics, provided combat identification.

3. ACT II Approach

Using cues from a Sentinel radar, the MFOS Testbed performed a "Slew to Cue". The imaging camera reacquired and tracked the target handed over from the radar. The ladar, which is boresighted to the tracking camera, measured its microdoppler (vibrational) signature. This vibrational signature, which is characteristic of the target's power plant, is used to classify the target. This platform classification is used with other target metrics to identify the target as friend or foe.

4.2 Test Results

4.2.1. Microdoppler Signatures

Live Ex II provided realistic, FAAD engagement scenarios against multiple airborne threats. These threats included rotor and fixed-wing targets. The microdoppler signatures of these targets were measured and documented during the airborne engagements. As an example of this capability, the LOFAR Gram (frequency of signal vs time; strength of the signal is shown by the darkness of the line) of the microdoppler signature of the a airborne target is shown.. The vertical scale is time, and the horizontal scale is frequency in Hertz.

Boeing's checkout aircraft is a Piper Cherokee. Its microdoppler signature (Figure 4.2.1.1.2-3) shows its microdoppler frequencies at 75, 150, and 225 Hz.

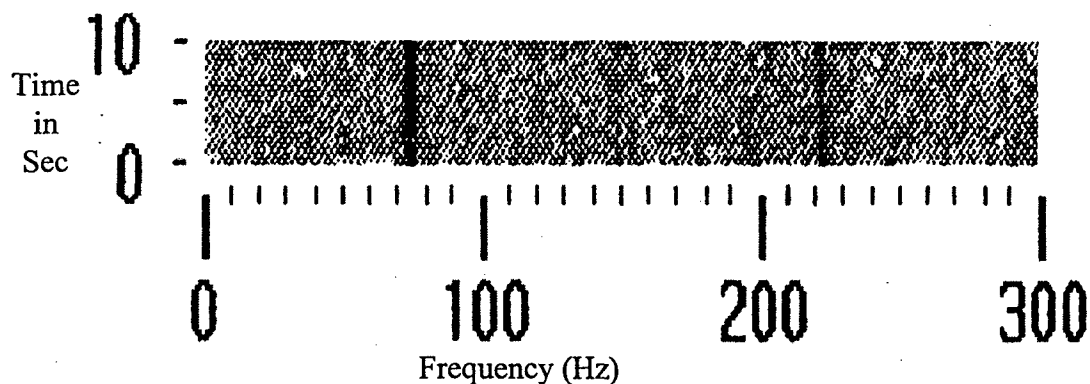
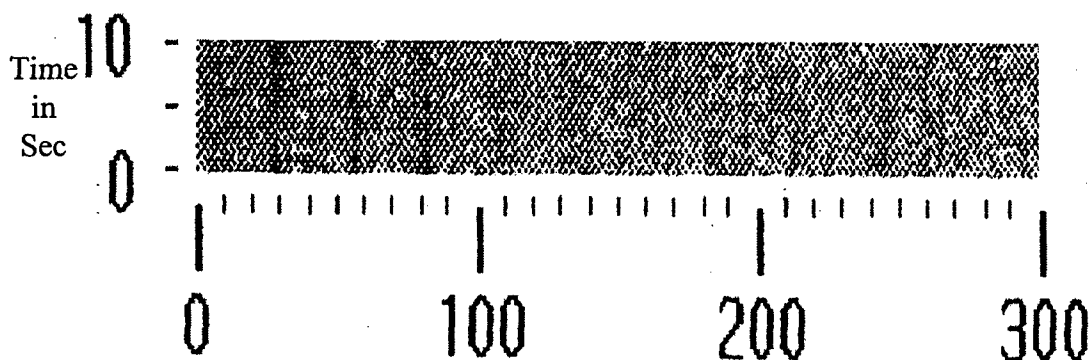


Figure 4.2.1.2-3 LOFAR Gram of Fixed-wing Piper Cherokee Target

The Long EZ aircraft's microdoppler signature, (Figure 4.2.1.2-4), shows the main rotor frequency at 82 Hz, with structural and noise lines at 29, 56, and 109 Hz. A Long EZ aircraft has a very streamline/low laser cross section shape.



Frequency (Hz)

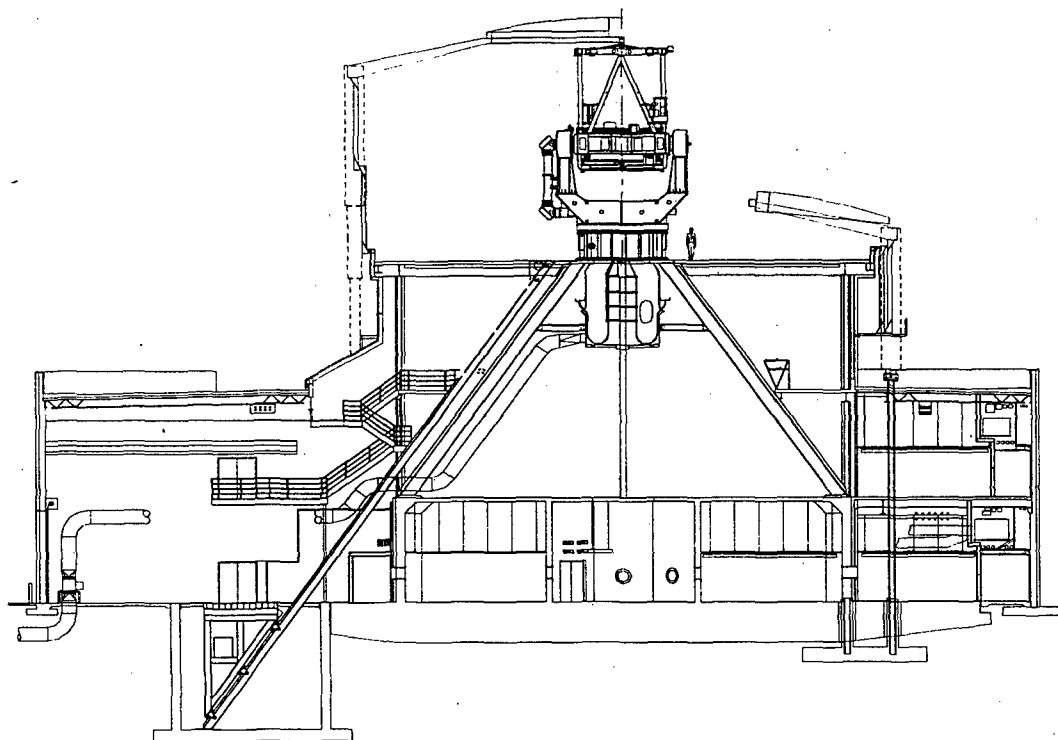
Figure 4.2.1.2-4 LoFar Gram of Fixed-wing (Long EZ) Target

4.3. ACT II Results

The results of this field test clearly demonstrated a microdoppler ladar adjunct to the Sentinel radar that is capable of providing non-cooperative target classification / identification at BVR (> 10km). The key to its operational effectiveness is the minimized time (latency) between Sentinel detection and microdoppler classification. Prioritizing of threats based on the threat's classification, range, direction, and speed will determine the engagement sequence used by the weapon systems.

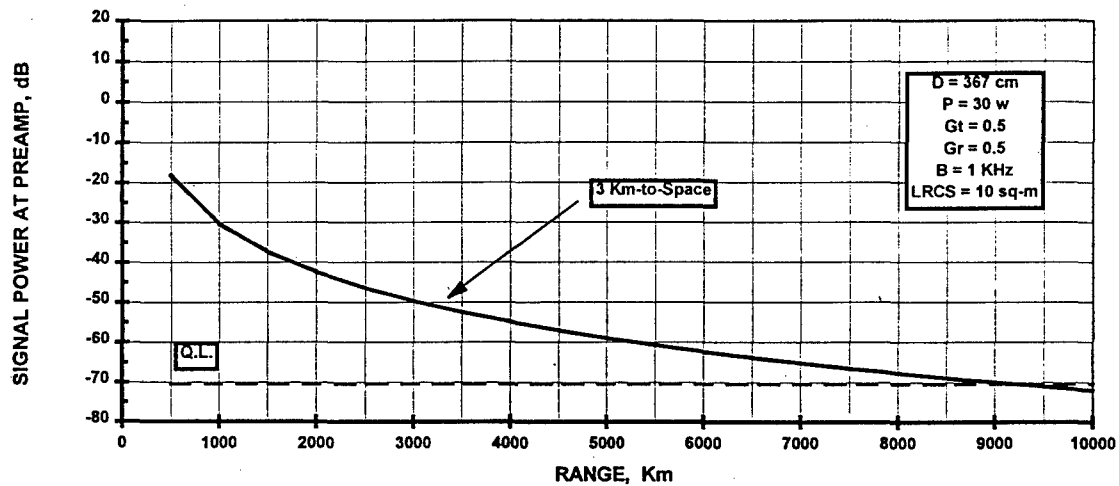
4.4. Application to Space Object Identification

Based on the signatures of tactical targets, an estimate of the laser cross section of space objects was made. Also the same ladar used for the Army ACT II would be integrated into the Advanced Electro-Optical System(AEOS) and use its full aperture(Figure 4.4.1).



The projected range performance is shown in Figure 4.4.2.

RANGE PREDICTION USING R4 MODEL



With a sensitivity < 100 micrometers per second it is expected that various vibrations will be measured. As part of the current Precision Targeting and Identification ACTD, a quick proof of concept is being reviewed for funding in 2000.

With higher laser power produced by a larger amplifier, ranges out to GEO can be achieved.